Background Report #1

# BACKGROUND REPORT
# ON
# DELTA ENVIRONMENT

A Report to the Delta Protection Commission

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# INTRODUCTION

The Delta Protection Commission is charged with preparation of a land use and resource management plan (Plan) for the Primary Zone of the Delta, as defined in the Delta Protection Act (see Figure 1). The Plan is to be adopted by the Commission and forwarded to the five Delta Counties (see Figure 2) for adoption and implementation through the existing regulatory process.
The Counties regulate land use through the General Plan and Zoning Ordinance, and through the day-to-day review of proposed projects. State and federal projects are reviewed through the environmental review process. By commenting on the environmental impacts of proposed projects, the Counties can attempt to ensure that the County plans and goals are implemented by all projects.
The physical characteristics of the Delta environment will be the basis Plan. The characteristics of the area--soils, elevation, geology--create a unique environment for use by humans and wildlife. This background report reviews the characteristics of the region before modification in the 1850's, describes the existing habitat types, describes the wildlife resources of the area, and describes the existing physical environment and how it influences land use.

Due to the extensive modifications to the Delta environment by humans, there are limits on the land uses of the area. The limits on land use have implications for management of the resources.
Due to the very limited budget and very short timeline allotted the Delta Protection Commission to complete the task of preparing the Plan, this report is based on existing references, albeit the latest and most up to date. For descriptions on the Delta habitats, aquatic resources, wildlife resources, geology and seismic hazards, the report relies on the information in State of the Estuary, prepared by the San Francisco Estuary Project in 1992. Information about soils was taken largely Land Subsidence in the Sacramento-San Joaquin Delta Literature Review Summary. prepared by U.S. Department of Agriculture, Soil Conservation Service in 1989.

## Chapter I: DELTA HABITATS

### 1. Historic Delta Environment (1)

Prior to 1850, the Delta existed in its natural, historic state. The region is the outlet of the Sacramento and San Joaquin River drainages, which drain 40% of the land area of California. Prior to any modification, approximately 27 million acre-feet (an acre foot is the amount of water it would take to cover one acre of land with one foot of water) of freshwater flowed annually through this drainage system, mixing with salt water from the ocean and Bay, resulting in a natural estuarine system that covered 1,300 square miles.

The heart of the Delta was extensive freshwater and brackish water marshes. Spreading inland from the wetlands were expanses of grasslands dotted with seasonal wetlands, oak-woodland savannah, and chaparral. Rivers and creeks, bordered by lush riparian vegetation, criss-crossed the area. Historic accounts of the region are full with references to the abundance of waterfowl, deer, elk, antelope, and other wildlife.

Due to the flat topography at the confluences of five rivers, the entire Delta was flooded from December to May (2). Another characteristic of the historic Delta, an estuary where fresh water and sea water meet, was the natural variations in the salinity in the water both seasonally and annually. In the Delta, freshwater flows into the mixing zone during the winter rainy season and during the spring and summer when the snows in the Sierra melt and flow downstream. In late summer and fall when the snows have melted and there is no or little rainfall, the salty waters would intrude further into the Delta. Sea water has a salinity of 3.5 percent, usually described in parts per thousand (ppt); 3.5 percent = 35 ppt. Freshwater has less than 0.5 ppt. Salinity ranges from 35 at the Golden Gate to 0 in the inflowing rivers. Years of heavy rain and snowfall would result in low salinity in the Delta; drought years would result in increased salinity in the Delta in the summer and fall.

### 2. Modifications to the Delta Environment (3)

The historic Delta environment has been modified in several ways. The changes have permanently modified the physical characteristics of the area. The first major change was the construction of levees, low at first and progressively higher, to keep the tidal waters off the land to allow farming. This reclamation was carried out under the California Swamp and Overflow Act of 1868 which financially supported these actions. Through levee construction starting in the 1850's and continuing to the early 1900's, and the basic character of the Delta was changed from marsh to farmland.

The second major change was the construction of upstream dams starting in the 1920's through the 1960's. This construction created a more predictable salinity regime—summer salinity can be controlled by releasing freshwater into the rivers in the summer and fall, and reduced sediment being carried downstream (see Figures 6 and 7). The dams are part of the local, State, federal, and special district water projects which use the natural Delta waterways and some artificial channels in the Delta to carry the freshwater of the Sacramento River southward through the Delta to the pumps which pump the water out of the Delta to users in the Bay Area, the Central Valley, and Southern California. Two-thirds of the population of the State of California gets part of its drinking water from the Delta. In addition, channels were deepened, widened, and created in order to enhance navigation through the Delta region.

The Delta is now predominantly farmland, laced with waterways of varying widths which are lined with levees. The farmlands are used by animals, insects, and birds in varying levels depending on the farming practices employed and types of crops grown. The levees support widely varied amounts and types of vegetation which provide habitat to wildlife. The waterways support about 28 species of native fish and 28 species of exotic fish, and other aquatic species.

### 3. Existing Habitat Types (4)

Existing wetland and terrestrial habitat types fall into one of three categories: habitats on the water side of the levees, including the channels, the channel islands (which are not leveed), and the water side of the levees; the levees themselves, earthen structures which must be maintained from time to time which may require removal of all or most vegetation; and habitats inland of the levees and at higher elevations around the outer edges of the Delta. These lands are largely in agricultural use including irrigated and non-irrigated grazing lands, irrigated row crops, grains, and permanently planted fruits and nuts. About 80% of the Delta is agricultural use; about 10% open water; and 10% is all other habitats including marshes, riparian areas, seasonal wetlands, and lakes (5).

The list of habitat types is based on the classification of Wetlands and Deep Water Habitats of the United States used in the National Wetlands Inventory system of habitat classification and include both terrestrial (land) habitats and aquatic (water) habitats. Current (1993) inventories of 38 Delta islands by a consultant to U.S. Army Corps of Engineers show that only 6% (14,641 acres) of total acreage supports native vegetation (6).

a.   Shaded Riverine Aquatic is all vegetation which overhangs the water, regardless of tide stage.  This habitat exhibits the combined characteristics of open water areas and riparian forests (see Riparian Forest).

b.   Scrub Shrub includes trees and woody shrubs and vines (alder, willow, wild rose, box elder, wild blackberries) less than 20 feet in height.  The characteristics of this habitat are more fully described under "Riparian Forest".  Where levee habitat has been disturbed due to maintenance construction activities which require removal of vegetation, the scrub shrub is the first phase of reforestation.

c.   Freshwater Marsh includes vernal pools and tule marshes found along the drainage ditches and other areas on the interior of levees.  The marsh plants may grow up to 15 feet tall; Delta marshes may have the largest plants of any tidal marshes in North America.  Tidal freshwater marshes often occur as unleveed islands in the Delta.  Tidal freshwater marshes are vegetated mostly with tule, reeds, and cattail, often intermixed with willow and other shrubby species.

The only habitat areas in the Delta which are very similar to the original habitats are the channel islands which are in the waterways.  These unleveed areas are of high wildlife habitat value due to their largely unaltered state and because they are directly related to aquatic habitats through the tidal interface (7).  Non-tidal freshwater marshes are found in the interior of the larger Delta islands.  They are associated with borrow pits, lakes, or drainage depressions.  The plant community of these marshes includes cattail, reed, willow, and bulrush.

d.   Riparian Forest consists primarily of broad-leaved deciduous trees and shrubs that grow adjacent to rivers and streams.  Some of the best examples occur along the Cosumnes River and the Beach/Stone Lakes area.   Under the canopy of cottonwood and western sycamore, which may reach heights of 100 feet, grow a variety of shrubs and vines such as willow, elderberry, and wild grape.  Some Delta islands also support mature riparian vegetation. By definition, riparian forest includes trees greater than 20 feet in height with a shrub, understory layer.  Corridors of riparian forest along stream and river channels enhance the value of adjacent aquatic habitats.  Their dense vegetation shades streams in the summer, moderating water temperatures.  The leaves and insects that drop in the water are important food sources for invertebrates and fish.

Riparian forest is the rarest of the wetland habitats, and is often described as the most valuable habitat for wildlife based on the availability of food, cover, water, and other critical habitat components, along with the diversity of the vegetation. In various studies, riparian habitats has been consistently found to support the greatest diversity of bird species. In a study of riparian areas in the Delta, more than 100 species of birds were identified.

e. Riverine Habitat includes vegetated shallow mudflats, shoals, submerged logs, and in-water vegetation such as pondweed, on the water side of levees. This includes intertidal areas between mean lower low water and mean higher high water. Composition of the mudflats varies from clay/silt to sand and includes organic debris and shell fragments. In the Delta, mudflats exist primarily in a narrow band lying below tidal freshwater marshes, although there are areas, as at the mouth of the Mokelumne River, where extensive mudflats form.

Mudflats support extensive and diverse communities of benthic invertebrates, fish and wildlife species. Benthic invertebrates-clams, worms, shrimp-occur in large numbers on and under the surface of mudflats. Because mudflats are highly disturbed areas, influenced by waves, currents, and variations in salinity, benthic communities are usually dominated by colonizer species that develop quickly, mature rapidly, and have high reproductive rates. During high tides, fish and others feed on these organisms. Mudflat vegetation is dominated by algae.

f. Cultivated Areas are the farmed areas of the Delta. Most of the cultivated lands in the Delta were originally freshwater tidal marshes. Annual and permanent crops are grown. Corn and grains are planted for commercial markets and by hunting clubs and farmers for wildlife food and cover. Today in the Delta, cultivated areas provide most of the food available to migratory waterfowl. During the winter, large numbers of waterfowl and shorebirds forage on the farmlands. Corn is probably the most valuable crop to waterfowl (8). In addition, programs between Ducks Unlimited and private property owners will result in over 15,000 acres of seasonally flooded croplands serving as flooded habitat for waterfowl (9). Other lands may be flooded as farmers leach fields of accumulated salts, for pest control, or for weed control.

The higher elevation agricultural lands are important to many species of raptors and wintering shorebirds, geese, swans, and cranes.

g. Open Water Areas are deepwater areas. The sediments in these areas range from fine silts and clays to coarse sand and gravel. The dominant plants of open water habitat are phytoplankton, which include diatoms, green algae and blue-green algae. In southern portions of the Delta, water hyacinth and water milfoil may grow in channels with slow-moving water.

Open water areas provide important habitat for many species of benthic organisms, fish, birds, and other animals. Anadromous fish species such as salmon and striped bass migrate through the open water habitat on their way to spawning areas.

h. Lakes and Ponds includes features including freshwater lakes, sewage treatment ponds, and reservoirs. Examples include: the Beach and Stone Lakes, City of Stockton sewage treatment ponds, Franks Tract, and Clifton Court Forebay. Plant communities vary, but are generally dominated by aquatic: vegetation, including floating, submerged, and emergent species, and duckweed, pondweed, and cattail. Delta lakes support diverse invertebrate communities of opossum shrimp, crayfish and amphipods. Of the artificial lakes and ponds, wastewater treatment ponds probably have the greatest potential for valuable wildlife habitat. Studies show that ponds in the Delta are used during the winter by many species of waterfowl, shorebirds, and other waterbirds.

4. Proposed Habitat Modifications

Many now view the flat, open Delta lands as valuable sites to reestablish wildlife habitat, particularly habitat for wintering waterfowl. While many farmers have managed agricultural lands in ways beneficial to migratory waterfowl, shore birds, and indigenous birds and mammals, some programs on agricultural lands promote management techniques and crops which are most appealing to and which provide the most food for the seasonal visitors. An example is the Central Valley Joint Habitat Venture Plan, prepared and adopted by U.S. Fish and Wildlife Service, Department of Fish and Game, Nature Conservancy, California Waterfowl Association, Ducks Unlimited, and others. On-farm methods include: controlled flooding, no burning of crop residues, and crop rotations.

Others see the Delta lands as appropriate location for areas to be returned to wetlands, such as managed wetlands, to provide year-round habitat for mammals and birds. In some situations, the wetland projects would be mitigation for adverse impacts caused by construction projects in other parts of the Delta or nearby areas. An example is the 100-acre mitigation site proposed by CalTrans near Stone Lakes (in the Secondary Zone). On islands with levees, restoration would require a source of funding for levee maintenance.

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Other projects would manage lands which currently have high wildlife habitat values to enhance and protect those values. An example is the proposed U.S. Fish and Wildlife Service Stone Lakes Wildlife Refuge, south of Sacramento and west of 1-5. Sometimes projects combine necessary elements with habitat enhancement, such as projects which create wetlands using treated wastewater from treatment facilities. An example is the wetland area at the Sacramento wastewater treatment facility (in the Secondary Zone); this concept may also be used in Contra Costa County, by Ironhouse Sanitary District on Jersey Island in the Primary Zone.

To increase the amount of riparian habitat, Department of Fish and Game and Department of Water Resources are studying creation of berms at the waterside foot of the levees and enlargement of the channel islands (10). Examples of this type of project are existing on Staten Island (San Joaquin County). These areas could be retained in their vegetated state in perpetuity, in contrast to the levees themselves which must be constantly maintained. Maintenance activities may result in removal of some or all vegetation on a levee. If berms and channel islands are created, they may reduce channel capacity, raising floodwater surface elevations.

# Chapter II.  AQUATIC RESOURCES

The extensive waterways in the Delta present a unique aquatic habitat with great variety.  The Delta has long been recognized as home to a great variety of fish and other aquatic organisms, and has hosted many species of exotics (non-native species).  Fishing has long been part of the human use of the Delta, from the early Native American inhabitants to today's recreational anglers (11).

Agricultural, municipal, and industrial diversions of the Delta waters have been part of human use of the Delta since the 1850's.

Aquatic resources--phytoplankton, zooplankton, benthos, and fishes--are all organisms that occur in Delta waters or sediments.  Each species plays an important role in the ecosystem and many have biodiversity, economic, or recreational values. The aquatic resources can be grouped into two categories: species that are directly harvested by humans or that support or inhibit the production of harvested species, and species that are valued for their aesthetic or biological characteristics.

All types of aquatic resources have been undergoing dramatic population changes and decreases.  The introduction of exotic species of phytoplankton, crustaceans, and fish have permanently altered the aquatic resources of the Delta.

## 1.   Primary Producers

Primary producers are the lowest level of the food chain. These are key elements in creating a favorable environment for others which are larger.

a.   Phytoplankton are very small, usually microscopic, single-celled members of the group of simple plants called algae. They range in size from less than one millionth of a meter to cells more than one millimeter.  Although most phytoplankton are photosynthetic (create food and energy from the sun), some supplement energy needs by assimilating dissolved organic compounds, detrital particles, or other organisms.  Phytoplankton are an important part of the aquatic food web and are consumed by zooplanktons, invertebrates, and some larval fish.

Phytoplankton growth and production in the Delta are controlled primarily by available light for photosynthesis.  The length of time that phytoplankton spend in adequate light is   -determined by several factors including: water depth and transparency, river inflow, freshwater export, and the net estuary circulation patterns.

In general, phytoplankton growth and abundance has declined in the Delta, and other nearby areas, since the mid-1970's. Although some of the declines represent natural variation and others have been caused by human activities, the causes are poorly understood. Low flows during the 1976-1977 drought resulted in extremely low phytoplankton levels in San Pablo and Suisun Bays, while the highest levels were observed entering the Delta in the Sacramento and San Joaquin Rivers. Since 1978, it appears that improved sewage treatment and increased flows from New Melones Reservoir have reduced the excessively high phytoplankton levels entering the Delta in the San Joaquin river. Also, a previously less-common phytoplankton--Melosira granulata--has dominated blooms in the Delta since the mid-1970's. This species is not preferred by zooplankton and in high concentrations clogs the filters of water treatment plants and causes taste and odor problems in waters.
A dramatic negative impact on phytoplankton abundance in the Western Delta and Suisun Bay has been the unintentional introduction of the Asian filter-feeding clam. Within two years of the clam's detection in 1986, phytoplankton levels were down by a factor of nearly ten. This clam, found at densities as great as 25,000 individuals per square meter, also appears to be affecting important zooplankton and other benthic species.

b. Zooplankton are generally free-floating aquatic animals. Most species are protozoans, rotifers, copepods, or cladocerans, and are quite small. The largest of these animals is about one-half inch long. There are over two hundred species of zooplankton in the Delta and San Francisco Bay. Many species are major food sources for fish and other organisms.

During the past decade, populations of many zooplankton species have declined in the Delta. Most species of copepods have undergone severe, long-term decline in abundance. Populations of the once-dominant native copepod--Eurytemora affinis--have plummeted, while two introduced species (Sinocalanus doerri and Pseudodiaptomous forbesi) presumably transported from the China Sea in the ballast water of commercial vessels, have greatly increased in numbers. Rotifer populations have sharply declined throughout the Delta, especially the San Joaquin River, where they were formerly most abundant. Cladoceran populations have also declined. Possible reasons for decline include: the droughts of 1970's and 1980'S; decreased phytoplankton abundance; increased water transparency; and introduced zooplankton and benthic species. Studies have found that Delta water exports probably had little effect on copepod populations.

c. Benthos. Benthic organisms are animals that dwell on or in mudflats, or at the bottom of the deep water areas. They range in size from microscopic unicellular flagellates to much larger organisms. Some burrow into the sediments/ some live on the surface of the sediments. Most benthic species are filter-feeders that feed by straining phytoplankton and detritus from the water column, while others graze on particles that settle to the bottom. Diversity is low in the Delta, where of the more than 82 benthic species recorded, five species (a clam, two amphipods, and two worms) account for some 90% of the individuals at most sites.

2. Crustaceans

Delta crustaceans include crayfish and small shrimp, both important foods to juvenile fish. Crayfish are harvested both commercially and for sport from the waters of the Delta. Signal crayfish were introduced into California from Oregon in about 1898. Signal crayfish prefer cool waters and are tolerant of salinities up to 17 ppt. They do not burrow and are most abundant in areas with rocky bottoms or other areas where cover is present. They grow slowly, not attaining a marketable size of 3 inches until two years of age. About 250 tons were harvested from the Delta in the early 1980's. Red swamp crayfish grow quickly reaching marketable size of 3 inches in 3 months. The red swamp crayfish dig 2-inch-in-diameter burrows as deep as 40 inches into dikes and streamsides and can tolerate salinities as high as 30 ppt. Two species of shrimp are found in the Delta. The native California Bay shrimp prefer the almost fresh water of the Delta and are common food for many fishes. The Palaemon macrodactylus, introduced from Korea, is found in the western Delta.

3. Fish

At the time of the Gold Rush, the pristine aquatic environment of the Delta provided habitat for large populations of salmon, steelhead trout, and scores of other species. The first commercial fisheries were established between 1848 and 1859, when Italian immigrants began to catch salmon. In 1863, the world's first salmon cannery was established in Yolo County, across the Sacramento River from the City of Sacramento. By the 1870's there was a desire to import new species to increase production. Striped bass and American shad were introduced at that time. Since the turn of the century, fisheries have declined as indicated by bans on commercial take of white sturgeon in 1901, steelhead trout in 1927, striped bass in 1935, and American shad in 1957. Today, no fish are commercially harvested in the Delta. The sport fishery is also in decline, although sport fishing is one of the most popular recreational uses in the Delta. Fifty-two species of fish have been identified in the Delta. Most were introduced from the East Coast, Asia, or Europe. Some are resident, spending their entire lives in the Delta channels (Delta smelt); others live in the Delta only at particular times in their life cycle (Chinook salmon).

Four species of fish have received special attention because of their commercial, recreational, or ecological value. Two of these are natives: Chinook salmon and Delta smelt; and two are introduced: Striped bass and American shad. Except the smelt, all are anadromous, spending a portion of their lives in salt water and returning to freshwater streams to spawn. These four species are discussed because their status represents the general devastation of the fisheries in the Delta. The heartbreaking diminishment of these four species is the subject of much study in the scientific and resource management fields. At this time there are no real answers; just much concern about the continued viability of the Delta's aquatic habitats.

a. Chinook Salmon, also called King salmon, has been highly valued for hundreds of years. The fish mature in the ocean, then migrate through the Delta to spawn in the gravel of streambeds in the Sacramento-San Joaquin river system. There are four runs, designated by season: a fall run that enters fresh water July to November and spawns in October; a late-fall run that enters fresh water October to February and spawns in January; a winter run that enters fresh water January to June and spawns in April; and a spring run that enters fresh water March to July and spawns in August. After hatching, the juvenile salmon travel downstream through the Delta to San Francisco Bay and on to the Ocean.
Each year 10 to 50 million juveniles, or smolts, enter Suisun Bay from the Delta. Historically, the fall run fish went to Sacramento River and the spring went to San Joaquin River. Dam construction on the rivers draining into the Delta have reduced the spawning habitat from 6,000 miles to 300 miles. During 1981-1989, the average annual total of all runs was 285,000, a decline of nearly 70% from historic levels. About 80% of all Chinook now are Sacramento River salmon; more than 90% are fall-run fish. The winter run has been nearly eliminated (from 120,000 to 191 in 1991) and has been listed on the federal and state endangered species list.

Factors leading to decline include the blockage of upstream migration by dams, degradation and loss of spawning habitat from fill and sedimentation, unscreened and inadequately screened diversions, acid mine drainage, and possibly pollutants in agricultural runoff. For the winter run, a particularly important factor is elevated water temperature in the Sacramento River during late spring.

To offset these losses, five hatcheries produce and release about 30 million young fish each year. The ocean commercial and sport salmon fisheries have been maintained by the hatchery fish. Hatchery fish were 2% of the catch in the 1950's and 60's, and more than one-third of the catch in the 1980's. Study of the hatchery fish point to two important conclusions. First, that ocean harvest rates are high and probably exceed levels that will produce the minimum sustained yield from populations dependent on natural production. Second, that natural stocks are being over-harvested. The fact is that without the hatchery fish spawn, natural production would be substantially less. There are long-term risks associated with the dependence on hatchery fish due to genetic fitness issues.

b. Striped Bass was introduced into the Bay/Delta area in 1879 and in 1882 from stock brought from New Jersey. Within a, decade, Striped bass were fished commercially. At the peak of the fishery, at the turn of the century, more than one million pounds of stripers were regularly taken each year, mostly from the Delta. The commercial fishery was ended in 1935, but the Striped bass has remained an important recreational fish. Striped bass are anadromous and spawn in fresh water. One-half to two-thirds of the eggs are produced in the Sacramento River, north of the City of Sacramento. The remainder are produced in the San Joaquin River, downstream of Venice Island. Spawning occurs in the Sacramento River from mid-May to mid-June and in the San Joaquin from late April through May. The eggs are carried downstream on currents. They hatch after two or three days and begin feeding on zooplankton, then opossum shrimp. In their second year, they eat Bay shrimp and smaller fish (including Delta smelt). The waters of the Suisun Marsh west of the Delta are a key nursery area for the juvenile striped bass.

In recent years, the number of Striped bass has dropped dramatically. In the early 1960's, the adult population was about three million, and in 1990 had dropped to about 500,000. The indicator of young Striped bass, the Striped Bass Index, has declined from a high of 117 in 1965, to 4.3 in 1990. The sport catch has also dropped from about 750,000 in the 1960's to less than 150,000 in the 1980's.

According to the Department of Fish and Game, reasons for the decline may include:

> Delta water diversion,
> Reduced Delta outflows,
> Low San Joaquin River inflow,
> Water pollution, toxic chemicals, and trace elements,
> Dredging and sediment disposal,
> Wetland filling,
> Illegal take and poaching,
> Diseases and parasites,
> Annual die-off of adult bass,
> Commercial Bay shrimp fishery, and
> Exotic aquatic organisms.

c. American Shad was introduced in 1871. Within eight years, it supported a commercial fishery. From 1900 to 1945, annual harvest frequently exceeded one million pounds. The population declined after 1945, and the commercial take was banned in 1957. The current adult population is estimated to be about three million, about one-third to two-thirds the population in the early 1900's. However, there are presently no sampling programs which provide a satisfactory measure of the shad population, so their status remains unclear. Shad is still a popular recreational catch in the Delta.

Shad historically spawned throughout the lower reaches of the Sacramento and San Joaquin Rivers. Today, the San Joaquin no longer supports significant spawning activity. The major spawning areas are the Feather, the lower American, and the Sacramento upstream of the American. Shad spawn in open water in May to June and eggs drift on the current until hatching in four to six days. In the Delta, young shad feed on zooplankton, including opossum shrimp.

Factors which have affected the decline of the shad may include:

Elevated water temperatures in the spawning and nursery areas, inadequate water quality in the San Joaquin River, Salinity increases, and Freshwater diversions.

d. Delta Smelt is one of the few remaining native species found in the upper reaches of the Delta. The delta smelt was designated "endangered" by the U.S. Fish and Wildlife Service in April of 1992 and is designated as "threatened" by the Department of Fish and Game. The range extends from Isleton on the Sacramento River and from Mossdale on the San Joaquin River, down river to Suisun Bay.

The smelt spawn in the sloughs and channels in the upper Delta. The embryos are adhesive, sticking to hard surfaces, such as rocks, gravel, and tree roots. Young and adult delta smelt inhabit surface and shoal waters of the main river channels where they feed entirely on copepods and other zooplankton. Prior to their sharp decline in abundance in 1984, delta smelt concentrated in the shallow water areas of the entrapment zone (the areas where the salty ocean waters and fresh waters meet and mix) in salinities ranging from 2 to 6 ppt (12). Since 1984, the entrapment zone has been located upstream of Suisun Bay in the deeper river channels and the smelt have also moved upstream.

The Delta Smelt Index shows a dramatic drop in population from 1650 in 1981, to 400 in 1990. Factors for the decline include:

Decline in natural food supply,
Entrainment (Delta smelt virtually never survive entrainment),
Reverse flows in the San Joaquin River,
Possible predation and competition from non-native species, such as Inland silverside and Striped Bass,
Increased salinity,
Diversion of freshwater.

4. Future Programs to Protect and Enhance Aquatic Habitat

The scientific, resource management, and water management fields are all carefully studying water resources to determine means of protecting the existing species and improving the overall aquatic health of the Delta.

In addition, several pending lawsuits and new federal guidelines are intended to positively affect aquatic habitat. Recent court actions mandate release of water from Friant Dam to enhance aquatic habitat in the San Joaquin River (13).

Programs currently being proposed include:

Release of additional freshwater from upstream dams.

Dredging and installation of temporary dams to promote water circulation.

Possible creation of new shallow areas for spawning, for example in the form of new berms constructed on the water sides of levees or by filling old dredger cuts.

The Department of Fish and Game's special anti-poaching program to protect against catching fish in the Delta for commercial sale, and against use of ocean fishing equipment, such as set lines or gill nets.

# Chapter III. WILDLIFE RESOURCES

According to historic sources, the Delta supported rich and diverse wildlife populations prior to 1850. Many species were associated with the hundreds of square miles of freshwater marsh in the Delta. The riparian woodland that grew on the higher, natural alluvial levees along the periphery *of* the Delta were extremely valuable in terms of diversity of species. Accounts describe multitudes of waterfowl "darkening the surface of the bays" and white geese giving the ground the appearance of being covered with snow (14).

The Delta was home to large numbers of fur-bearing mammals including beaver, river otter, bobcat, and raccoon. Trappers over harvested the beaver in the Delta and hundreds of thousands of waterfowl were harvested for commercial sale. Delta habitat was also changed dramatically with the advent of land reclamation for agriculture, and the start of hydraulic mining which washed millions of cubic yards of silt and sediment into the Delta and downstream. In the Delta, 320,000 acres of tidal freshwater marsh and riparian habitat were reclaimed for agriculture, eliminating nearly all of the marsh habitat and reducing populations of birds and mammals dependent upon them. A listing of wildlife species now found in the Delta is attached:

## Appendix A.

1. <u>Birds</u>

Clearly the conversion of wetlands and riparian corridors to farmlands has severely restricted and modified habitat for bird life. Historically, bird populations consumed native seeds and grains in the wetland and riparian areas. Substantial numbers of species and large numbers of individuals continue to use the Delta as permanent and seasonal habitat and have adapted to the agriculturally-influenced environment and landscape.

As noted previously, the riparian habitat still supports many types of birds and many birds live in the agricultural areas. Species include Great Blue Heron, with a colony is located at North Stone Lake, and Great Egret, with a colony at North Stone Lake and a colony at Sherman Island.

Waterfowl use the Delta as an important staging and wintering area in the Pacific Flyway, the vast area used by migratory birds to travel between breeding grounds and wintering areas (15). Waterfowl in the Delta during the period 1981 to 1990 included: Northern Pintail (35%); Geese (27.2%); Tundra Swans (17.1%); other Dabbling Ducks (10.5%) and Diving Ducks (8.6%) (16). The annual inventories show that the Delta provides habitat for 10% of the State's wintering waterfowl. Use in the Delta is limited early in the season and peaks later in the fall and winter. Use appears to be related to the time of flooding. The Delta is the most important wintering area for tundra swans within the Pacific Flyway.

Dabbling ducks include: mallard, gadwall, American wigeon, green-winged teal, cinnamon teal, and northern shoveler. Diving ducks include: redhead, canvasback, ring-necked duck, greater scaup, lesser scaup, common goldeneye, Barrow's goldeneye, bufflehead, ruddy duck, and others. Breeding populations of mallards, pintail, and wood ducks inhabit in the Delta.

The wintering waterfowl move about based on weather conditions, water conditions, food availability, time of flooding, and season. When the winter rains begin, waterfowl leave Suisun Marsh, Napa Marsh, and San Pablo Bay, and move to the Delta and other areas. Large numbers of birds come to the Delta when farmers begin to flood their agricultural fields; early flooding attracts large numbers of waterfowl.

The Delta agricultural land provides valuable habitat for wintering waterfowl. In the past 25 years, major crops have shifted from potatoes, asparagus, and tomatoes to corn, sorghum, alfalfa, and pasture grasses. These new crops favor waterfowl by providing greater amounts of food and are supporting larger concentrations of waterfowl in the Delta. The waterfowl will eat the grains available. In the Delta, corn is abundant, however, further north, waterfowl consume rice. Much of the value of agricultural lands in the Delta result from the practice of flooding fields in the winter to leach out salts and to control weeds and insects. Because corn, probably the most valuable crop to waterfowl, is among the most salt-sensitive, corn fields required regular leaching. Generally about 25% of the Delta islands are flooded by mid-December and this coincides with normal peaks in waterfowl use. In general, geese and swans make the most use of flooded agricultural fields.

Nonflooded agricultural fields are secondary in importance. However, both white-fronted and snow geese prefer to feed in open, nonflooded corn fields.

Golden eagles live north of the Delta and hunt in the open, flat lands within the farmed lands. Loss of habitat has been a major cause of decline of the golden eagle, along with shooting, collisions and electrocution, lead poisoning, and human disturbance of nest sites.

Bald eagles live outside the Delta in the Cosutnnes River area. Current threats to bald eagles are collisions with towers and powerlines, shooting, poisoning, and electrocution.

Swainson's Hawk was designated "threatened" by the State of California in 1983. Swainson's Hawk adapt to foraging in agricultural fields, pastures, and fallow areas. About 9% of the State's population nests in the Delta west of Stockton on Middle Roberts, Union, and Coney Islands; along Steamboat Slough and the Sacramento River from Isleton north to Courtland; and at the confluence of Dry Creek, the Mokelumne and Cosumnes Rivers and Snodgrass Slough. Adverse impacts include loss of nesting habitat due to levee maintenance and associated vegetation removal, urban and agricultural expansion, and conversion to crops such as vineyards and orchards which restrict foraging.

Greater Sandhill Cranes winter in the Delta. Over two-thirds use the Delta as a wintering area. Roosting areas include Brack Tract and Staten Island. Sandhill Cranes have been known to die after collisions with powerlines in foggy conditions.

Shorebirds also use the Delta. Shorebird use is dependent on agricultural practices, especially crop patterns and the flooding of fields. Extensive early fall and spring flooding of plowed fields can result in large concentrations of shorebirds. At least 27 species occur annually in the Delta. Killdeer, black-necked stilt, American avocet, snowy plover, and spotted sandpiper are the only nesting species. Others are seen only during migration or in winter.

2. Mammals

Many mammals reside in the Delta area, although the numbers are severely reduced from 1850 and some species-bear, elk--have been extirpated. Muskrat, beaver, and mink are still hunted for their pelts. Mammals that burrow into the levees are unpopular with reclamation districts. Some of the mammalian inhabitants of the Delta are coyote, skunk, raccoon, opossum, ground squirrel, riparian brush rabbit, San Joaquin Valley woodrat, ringtail, and aquatic species such as beaver, muskrat, mink, and river otter. Feral cats can be found near developed areas.

3. Other Terrestrial Species

a. Amphibians generally occur in marsh or riparian habitats. Due to loss of these habitats, amphibian population is limited. Salamanders occur in upland habitats. The native red-legged frog has been designated as a special status species. Bullfrogs, an introduced species, are now abundant and are collected for human consumption. California tiger salamander, which sometimes use farm ponds for breeding, is designated a "species of concern".

b. Reptiles Most reptiles live in upland or agricultural areas. The only aquatic reptiles are western pond turtle, western aquatic garter snake, and giant garter snake. Reptiles are the only animal group in the Delta with no introduced species.

c. Insects A variety of insects are common in the Delta, many of which are associated with crops grown in the Delta and are controlled as part of agricultural land management.

The Valley Elderberry Beetle lives in riparian woodlands. Due to limited riparian habitat, the beetle is listed as a federal "threatened species".

Mosquitos continue to thrive in moist habitats in the Delta, representing both an irritant and health hazard to humans. The life cycle of mosquitos is directly related to water applications and can be controlled by water flow, depth, and circulation; by introduction of predators (mosquito fish); and by application of control agents. Substantial public funds are dedicated to controlling mosquitoes. Programs are carried out Mosquito Abatement Districts, special districts with elected Boards of Directors.

4. Factors Adversely Affecting Wildlife Populations

The major determinants of wildlife abundance and distribution include habitat loss and degradation, hunting, disease, predation, pollutants, competition from introduced species, and human disturbance.

a. Habitat Loss and Degradation. Quantity and quality of habitat is one of the most important factors determining the size and health of wildlife populations. Since 1850, wildlife habitat has changed and been diminished dramatically; 97% of the original tidal wetlands in the Delta have been converted to farmland or other use.

Modern farming methods allowing earlier maturation of crops, and thus earlier harvesting have affected birds that nest in agricultural fields.

Transition from field crops to permanently planted crops, such as vineyards, have also affected usefulness of agricultural lands for wildlife habitat; the food products have less value and the form of the plants prevents use by many birds. The vegetation on levees must be removed from time to time to allow maintenance of Delta levees and in the last decade, most of the Delta levees have been upgraded resulting in loss of much vegetation from levees.

Erosion has resulted in loss of habitat on the water side of levees, berms, and channel islands. Erosion of Delta levees is caused by natural forces, water transfers, and recreational uses. Placement of riprap to protect against erosion has resulted in loss of some habitat. Sea level rise as a result of global warming could result in loss of low elevation berms and channel islands. Construction of roads, pipelines, canals, and electric lines create barriers to travel which can result in loss of life.

b. Hunting. Hunting results in substantial take of waterfowl. However, hunters' fees support state and federal programs which help provide habitat for waterfowl and provide education and management programs which result in more and better managed areas for waterfowl habitat thus protecting overall population. In addition, lands which are hunted seasonally are managed to maximize habitat values for all avian species. Hunting of fur-bearing species dramatically dropped during the 1980's--20,554 in 1980 to 2,259 in 1988 (17).

c. Disease. Disease is a major cause of death among waterfowl wintering in the Delta and throughout the State. The effects of disease are compounded if populations are concentrated in increasingly small habitat areas. Overcrowding, poor habitat quality, and adverse weather contribute to the spread of diseases such as avian cholera and botulism. The Delta is one of two areas considered a focal point of avian cholera. It is believed that the gradual expansion in the range of cholera outbreaks during the past 35 years may reflect interactions among the disease, habitat deterioration, and increased pollution from chlorinated pesticides.

d. Predation. Effect of predation is usually most pronounced during the breeding season and on populations already reduced in numbers and existing in poor habitats.

e. Pollutants. Pollutants include trace elements and persistent organic chemicals. Another source of pollution is fuel spills from vessels in Delta waters.

f. Introduced Species. Species that have been introduced are now competing with and affecting populations of previously established wildlife, yet introduced species are some of the most popular with fishermen (American shad, Catfish, and Striped bass). Introduced species such as the Asian clam are affecting the composition of the benthic community, thus affecting food web relationships. The result of the introduction of this species may affect fish, birds, and waterfowl in the Delta area.

g. Human Disturbance. Waterfowl are disturbed by hunters on the ground, fishermen, and boaters,- public access may disturb nesting birds. Agricultural activities such as mowing and harvesting adversely affect birds which nest on the ground.

5. Opportunities to Enhance Wildlife Habitat

Several means of enhancing wildlife habitat have been identified by wildlife managers and scientific experts. To increase wildlife populations, programs focus on increasing the amount and quality of habitat.

a. Increase Acreage of Seasonally Flooded Agricultural Land. One major program for enhancing habitat, particularly for wintering waterfowl, is the Central Valley Habitat Joint Venture, a program developed by State and Federal wildlife agencies and non-profit groups to increase acreage in grains, which serves as food for migratory waterfowl, and increase winter flooding of those lands to serve as feeding and resting areas. The program has set a goal of about 40,000 acres of winter flooded lands in the Delta. Other groups and individuals are voluntarily partaking in such activities. An outstanding example is the 9,000 acre M & T Staten Ranch which voluntarily floods its fields in fall and winter; January 1993 bird counts showed 80,000 ducks, 20,000 geese, 5,000 tundra swans, and 14,000 lesser and greater sandhill cranes on the Ranch. Almost 80% of the Pacific Flyway's greater sandhill cranes, a threatened species, winter on and around Staten Island (18). Careful management techniques must be followed to ensure that risks to human health from increased mosquito production are minimized.

b. Increase Acreage of Wetlands. In some areas of the Delta, plans are underway to enhance existing seasonal wetland areas and to create new managed wetland areas in lands that were once used for agricultural purposes. The Stone Lakes Wildlife Refuge proposes enhanced management of seasonal wetlands and will manage areas of newly created wetlands, such as a 100-acre managed wetland currently being proposed by CalTrans in the Secondary Zone near Stone Lakes. Hunting would not be allowed in the Refuge and public access would be provided, but controlled and limited. In addition, there are proposals to convert Twitchell Island into a managed wetland, convert parts of Sherman Island to managed wetland, and seasonally manage Holland and Bouldin Islands as waterfowl habitat (part of the year the Islands would be reservoirs). Hunting is a key component of the management and use of several of these Islands. Careful management techniques must be followed to ensure that risks to human health from increased mosquito production are minimized. Loss of riparian wetlands has been dramatic. Several programs are underway to replant areas to re-establish riparian vegetation along waterways.

c. Discourage Introduced Species. There are many introduced species in the Delta; many of which aggressively compete with native species. It is difficult to remove exotic species once they are established. Introduction of exotic species is one dramatic factor of change in the Delta since 1850; one that cannot easily be modified.

d. Control/Reduce Disease. Creation of larger, well-managed areas for wintering waterfowl should diminish the spread of disease. Careful management of the permanent and seasonal wetlands will protect the quality of the habitat by preventing pollution either from water or from land-based activities.

e. Reduce Predation. Creation of larger areas for habitat will also increase the chance for survival of wildlife, such as ground nesting birds. Where nesting areas are limited to a narrow band of habitat along a cultivated field, predators have a high likelihood of locating nests. Controlling harvesting dates to allow maximum number of eggs to hatch in nests located in agricultural fields will also enhance survival rates.

## Chapter IV. PHYSICAL FEATURES

### 1. Geology (19)

The geology of the Delta area is the physical framework of the area. The geology defines the underlying physical structure of the area and the natural factors and processes, such as soils, elevation, seismicity, and tendency toward flooding.

The geologic processes contributing to the Delta's formation include movements of the earth's crust during the past 150 million years that transformed the region from deep ocean to continental hills and valleys, and creation of a bedrock trough in which lies San Francisco Bay. Although the origins of the area date back to the early Pliocene Epoch, some 10 to 12 million years ago, the Delta has existed for only about 5,000 years.

Sea level fluctuations played an important roll in formation of the Delta. Evidence from core samples indicates the area has gone through at least three cycles of emergence and submergence in the past million years. At the end of the last glacial period, 15,000 to 18,000 years ago, the seas began their most recent rise. At that time, the shoreline of the Pacific Ocean was beyond the Farallon Islands. To reach the Ocean, the Sacramento and San Joaquin Rivers flowed past Angel Island and the Golden Gate and crossed the continental shelf for more than 20 miles.

About 10,000 years ago, sea level began to rise. Initially, the rise in sea level was rapid, averaging nearly 0.8 inches each year and sea water advanced across the basin floor at a rate of nearly 100 feet each year. About 5,000 years ago, as glaciers reached approximately their present size and the rise in sea level slowed markedly, waters were about 25 feet lower than their present level. In the intervening 5,000 years, the sea continued its slow rise and the estuary eventually reached its current elevation. Many scientists believe sea level is continuing to rise.

The Sacramento-San Joaquin Delta formed in an unusual way. Unlike most deltas, which grow seaward as sediments are deposited at river mouths, the Sacramento-San Joaquin Delta formed far inland from the ocean and grew in an upstream direction. The Delta was caused by a barrier of bedrock at the Carquinez Strait which trapped sediments carried by the Sacramento and San Joaquin Rivers. As the sediments accumulated at the confluence of the two rivers, there evolved a 540-square-mile freshwater marsh on some 80 islands surrounded by hundreds of miles of channels. Without the barrier, the sediments would have washed downstream.

The natural landforms included low levees or berms of mineral soils about five feet above sea level alongside the major channels. The islands were much as they exist now, but with low-lying wetland areas in the center.

### 2. Soils (20)

Soils are a key resource of the Delta area. While the Delta soils define the area as a valuable agricultural area, past soil management practices have resulted in subsidence of the peat soils in the central Delta. Better management of peat soils is a key to long-term management of the central Delta area.

The soils in the outer edges of the Delta are usually comprised of well-drained loam, sandy loam, and clay loam soils. These soils are usually level to sloping and are the periphery of the Delta. Sandy soils are also located in the channels of the main waterways of the Sacramento River.

Much of the Delta has organic soils, including peat, organic silt, organic clay, and mineral soils containing more than 25% organics. Delta peat soils are mostly fibrous, formed from tules and reeds, formed in open water from plants, pollen, and leaves. Delta peats contain a high proportion of cellulose and have a high water-holding capacity. Delta peats contain from 2% to 3.5% nitrogen and when drained make excellent agricultural soils. The depth of the soils is up to 40 feet thick. The areas with the deepest organic soils include Southern Grand Island, Southern Tyler Island, Southern Brannan Island, Twitchell Island, Northern and Southern Sherman Island, Venice Island, Medford Island and eastern Bouldin Island (see Figure 8). The earliest organic soils in the Delta have been carbon dated at about 11,000 years of age.

The organic soils formed on five different geologic materials: granitic and sedimentary deltaic deposits of the Sacramento River; granitic and metamorphic sedimentary deltaic deposits from the Mokelumne River system; fine granitic sedimentary deltaic deposits from the San Joaquin River; eolian and metamorphic deposits of the Coastal Range; and deep estuary fine grained sediment deposits from the combined deltaic systems.

The organic soil is subject to subsidence, a decrease in land surface elevation. Nine different causes of land subsidence have been identified. The surface processes include: microbial decomposition, shrinkage, wind erosion, anaerobic decomposition, and burning. Where oxidation rates are greatest, making it infeasible and uneconomical to continue farming, consider retiring some lands from agriculture to wetland habitat restoration, water storage, or recreation.

b. Shrinkage. Organic soils shrink up to 50% in volume when they become thoroughly dry. DWR estimates overall subsidence to be one to three inches per year and that most of the overall subsidence is from surface loss (microbial decomposition and wind erosion). When surface loss occurs, the water table is lowered by an amount equal to the loss, thus exposing more soil to subsidence from shrinkage. Shrinkage depends upon oxidation to expose new soil for shrinking.

To control shrinkage, keep water level or soil saturation as close to the surface as possible.

c. Wind Erosion. Under certain conditions, wind erosion in the Delta can be very severe, but is currently considered a minor contribution to subsidence. Dry organic soils are very light and easily blown. In the 1950's and 1960's over 90,000 acres were devoted to white asparagus cultivation where dry organic soil was hilled up around the plants. The soil was subjected to wind erosion from mid-April to mid-June, the windiest time of the year. Studies at that time determined that wind erosion accounted for about 0.1 inch of soil loss per year. Growers planted barley as windbreaks in the asparagus fields which reduced wind erosion about 80%. Most of the current wind erosion is from open, plowed fields.

To control wind erosion, maintain vegetative cover or water cover during windy periods; install windbreaks; use inter-row plantings of tall, early growing small grains; use crop residues; and use conservation tillage (minimize the number of times of tilling per year).

d. Anaerobic Decomposition. Studies in the 1960's found that the cycle of wetting and drying organic soil actually accelerates the rate of decomposition resulting in subsidence. Considerable decomposition takes place immediately below the groundwater table, particularly if the groundwater table is subject to rapid fluctuation. Anaerobic decomposition is currently deemed very minor.

To control anaerobic decomposition, various agents can be used to negatively affect microfauna and bacteria. In some areas, adding agents will not work and agents should not be applied in areas where water quality is a consideration.

Deep subsidence results from tectonic movement, consolidation from Natural gas withdrawal, and natural consolidation. Studies indicate that deep subsidence is *a* small part of the overall subsidence problem; more than 75% of the total subsidence of Delta organic soils is due to microbial decomposition, caused largely by agricultural activities (21). Current studies by the Department of Water Resources (DWR) and U.S. Geological Survey reinforce indications that drying the soil and increasing temperature are key factors in subsidence (22).

Farming of the Delta dates from the passage of the Swamp and Overflow Act of 1850. The first levees were built in the late 1860's and by 1920 the Delta was almost entirely in cultivation. By 1922, it was already apparent that the clearing, draining, and tilling had caused appreciable subsidence of the Delta islands. A University of California study published in 1950 stated that the islands studied had subsided 4.5 to 6.5 feet and were continuing to subside at a rate of 3 to 3.5 inches per year. DWR studies in 1980 indicated that the central Delta had subsided 10 to 21 feet by 1980 and that subsidence continued at rates of from one to three inches per year (see Figures 9 and 10).

a. Oxidation. The formation of organic soils depends upon the existence of poor drainage conditions over an area for a long period of time. These conditions occur in marshes where the rate of plant growth is greater than the rate of plant decomposition. Oxygen is excluded from the soil by excess water and in this anaerobic environment, decomposition is slower.

When organic soils are drained and cultivated, oxygen is introduced into the soil and the tilling of soil changes the condition to aerobic conditions where microbial decomposition is vastly accelerated. Tillage is not, however, essential to the oxidation process. Subsidence has occurred where soils have not been tilled in years.

Two primary factors in the rate of subsidence are temperature and moisture. Microbial decomposition increases with higher temperatures and decreases with higher moisture. DWR staff believes the most effective means for controlling microbial decomposition is permanent inundation.

To control oxidation, control water level as close to the root zone as possible (two feet or less below the ground surface during cropping season) and raise to ground level when crops are off.

In addition, inland of levees leave a wide wetland/wildlife strip, maintained as permanent wetland. SB 34 gives the DWR the authority to acquire easements up to 400 feet in width along levees to control subsidence.

Where oxidation rates are greatest, making it infeasible and uneconomical to continue farming, consider retiring some lands from agriculture to wetland habitat restoration, water storage, or recreation.

b. Shrinkage. Organic soils shrink up to 50% in volume when they become thoroughly dry. DWR estimates overall subsidence to be one to three inches per year and that most of the overall subsidence is from surface loss (microbial decomposition and wind erosion). When surface loss occurs, the water table is lowered by an amount equal to the loss, thus exposing more soil to subsidence from shrinkage. Shrinkage depends upon oxidation to expose new soil for shrinking.

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To control anaerobic decomposition, various agents can be used to negatively affect microfauna and bacteria. In some areas, adding agents will not work and agents should not be applied in areas where water quality is a consideration.

e. Burning. Prior to 1950, it was common practice to periodically burn off the upper three to five inches of soils to clear the fields and destroy weeds, weed seeds, and plant pests. A 1950 study determined that every part of the study area had been burned at least once to a depth of three to five inches and some areas were burned three to four times. Currently, burning is less widespread and more controlled. Some farmers burn over damp soil to protect the soil. DWR estimates the rate of soil loss from burning was approximately 0.1 inches per year on fields that were burned. Burning is also a hazard to residential and other uses of the Delta, as the peat soils can burn underground for long periods of time.

To eliminate burning loss, stop use of burning as a maintenance tool.

3. Classification of Soils for Agricultural Use.

Local governments work with the State government to protect soils deemed most important for agriculture. Under the "Williamson Act", soils are studied, and designated by the *Department of* Conservation. Lands which qualify can enter into an agreement with the Counties which result in lowered property taxes, a key factor in protecting agriculture. The Department of Conservation also monitors conversion of agricultural land to other uses.

Local governments have used soil designations as one of the key factors for categorizing land in their General Plans and Zoning Ordinances. It is very difficult to return land to agricultural use once it has been developed for other uses such as residential or commercial use. There is a finite amount of agricultural land in California and prime agricultural soil has long been recognized as a key State resource.

Soil is categorized by the State and Federal governments as to its suitability for commercial agriculture. The best, most valuable soils are called "prime". The factors used to analyze land in the Important Farmland Inventory (IFI) include (23):

Reliable supply of water;
Warm temperature range and long growing season;
pH level within the root zone between 4.5 and 8.4;
Water table at a depth sufficient to allow crops to grow;
Sodium content of less than 15% and measure of electrical conductivity;
Flooding no more than once every two years;
Low soil erodibility and slope of less than 2%
Soil permeability of 0.15 centimeters per hour in the top 20 inches;
Limited rock fragments; and
Minimum rooting depth of 40 inches.

The IFI includes four categories: prime agricultural lands; lands of statewide importance; unique lands; and lands of local importance.

Within the legal Delta, including the Secondary Zone, the Department of Conservation has documented 60% of the area, or almost 450,000 acres, as "prime" land. Another 100,000 acres of land are classified as lands of statewide importance, unique agricultural lands, or lands of local value (24)

U.S. Department of Agriculture uses Land Capability Classification (LCC) System to group soils into eight categories (Class I-VIII). The LCC is often used in precise soil surveys of individual sites and is based on: soil depth; surface layer texture; permeability,- drainage; water holding capacity; erosion hazard; flooding hazard; salinity; alkali levels; toxic substances; slope; frost-free days; and climate indicators. Class I soils have virtually no limitations; Class II soils have some limitations. Class I and II are often grouped together as "prime" farmland.

4. Seismic Hazards (25)

The earth's surface is comprised of plates. Faults located along these plates move causing seismic hazards. There is no way to modify seismicity; only ways to minimize damage from seismic activity. Because some of the Delta levees were originally built over 100 years ago on soft peat soils and sands, there are inherent dangers to the levees. If levees are damaged in a seismic event, there could be extensive damage to crops, physical property, utilities, drinking water, and to human life.

There are no active major faults in the Delta region, however, there are several significant faults outside the area which could affect the Delta area. While there is no documented failure of a Delta levee associated with earthquake activity, the Delta area is particularly vulnerable to seismic events. If levees were damaged, or weakened by a seismic event, the ultimate impact could be widespread flooding, and crop and property damage.

The San Andreas Fault, site of the 1989 Loma Prieta earthquake, is located about 60 miles west of the Delta. Movement associated with the Loma Prieta earthquake was felt in the Delta area.

The Sunol-Calaveras Fault and the Hayward Fault are located along the east shore of San Francisco Bay. A series of faults and fractures, including the Green Valley Fault are located in the Solano County area, west of the Delta. Additional faults are located under the west end of the Delta, continuing northwesterly of Sacramento. Another series of faults are located 30 miles east of Sacramento.

DWR is continuing to study seismicity in the Delta and recently started a program to install four seismographs. DWR believes that levee axis may play an important part in shock effects. Levees in which seismic movement strikes broadside may be more susceptible to collapse than when shocks are more parallel. Studies also seek to confirm the hypothesis that peat soils generally dampen seismic energy levels.

The unconsolidated nature of the foundation substrate of some of the levees is susceptible to liquefaction or deformation due to earthquake shaking and potential liquefaction; many of these levees are located in the northern and eastern portions of the Delta. In addition, the levee construction material is generally unconsolidated silt, sand, organic soils, and mud which may exacerbate vulnerabilities in the foundation.

5. Flooding

Flooding is an important public safety issue which is addressed by local, as well as State and federal programs. Many Counties use a flood hazard overlay to address and direct land uses in flood prone areas. The Federal Emergency Management Agency (FEMA) program identifies flood prone areas and carries out a national flood insurance program. FEMA publishes a series of maps identifying these areas.

Flooding was a natural occurrence in the pre-1850 Delta. Flooding in the Delta occurs in two ways. First, there is tidal fluctuation twice a day which raises and lowers the water surface in the Sacramento River by about three feet (see Figure 11). Secondly, seasonal flooding occurred when rain in the watershed exceeded the flood carrying capacity of the river channels and spread over the low-lying lands of the Delta. Seasonal flooding carried fine sediment onto the Delta islands where the waters slowed down and dropped the sediment.

The frequency of flooding was greatly increased by hydraulic mining in the late 1800's. Billions of tons of silt, sand, gravel, and cobbles were washed into the valley rivers for years, obstructing the rivers and greatly reducing capacity to carry floodwaters.

As settlers developed the area, small levees, then larger levees, were built to reclaim land and to divert water off individual parcels. By the 1860's, landowners had grouped together to create reclamation districts for joint flood control. By 1910, Sacramento Valley and Delta landowners had built 28 million dollars worth of flood control works at their own expense.

As early as 1884, flood control began near Auburn. This private effort helped set the pattern for flood control programs. In 1894, a valley-wide approach to flood control was developed including a bypass system, escapeways, and bypass levees. In 1911, the State adopted a master plan to construct a series of leveed river channels, weirs and bypasses, and created the Reclamation Board to carry out the plan.

The plan was adopted by Congress in 1917. The earliest features of the Sacramento River Flood Control Project were the Knights Landing outfall gates, the Sacramento Weir, and the Yolo Bypass.

The system has continued to control flows in the Sacramento River, however, recent studies (26) indicate that due to extensive development in the watershed, the design capacity of the flood control system may be at maximum capacity. New flood plain opportunities remain that may augment the channelized rivers.

Flooding has occurred in the Central Valley 27 times since the great floods of 1861-62, an average of once every five years. Since 1950 there have been 11 major floods, most recently in 1986 (see Figures 12 and 13). Eight major reservoirs have been constructed in the watershed which provide 19.3 million acre-feet of water storage, of which 7.5 million acre-feet is the maximum reserved for flood control during the rain and snowmelt season.

Approximately 15% of the levees in the Delta were built by the U.S. Army Corps of Engineers and maintained to federal standards. These levees are physically closest to the Cities of Sacramento and Stockton.

In 1988, the State approved the Delta Flood Protection Act. Under this program, monies were designated for improved flood control in the Delta. The program includes enhanced levee maintenance on the non-federal levees, with a larger percentage of the funding coming from the State (75%) to match property owner dollars (see Figure 14). In addition, DWR developed a special program to protect against levee failure on the eight westernmost islands in the Delta, those subjected to the strongest forces of wind and tide (see Figure 15). These islands are key for protection of drinking water exported from the Delta from saline intrusion. Special provisions were included for provision of flood protection for the existing communities of Thornton and Walnut Grove.

Flooding of the Delta, permanently or temporarily, would have very devastating, catastrophic consequences. Short-term flooding costs include: repair of levee break; pumping costs to remove water; possible need to "flush" Delta with freshwater to remove saline water to return waters to drinking water standards; loss of crops; loss of structures; possible impacts to county, state or federal roadways and bridges; impacts to regional powerlines gas pipelines, petroleum pipelines, railroads, and other infrastructure, and loss of freshwater supply to large parts of the Bay Area, Central and Southern California. Long-term flooding would also impact the overall water quality in the Delta and would result in permanent loss of wildlife habitat, as well as the impacts listed above. The State's position is that no more islands can be lost in the Delta.

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Environment Findings: *

F-l. The physical environment which existed prior to 1850 has been permanently and irretrievably modified through levee construction, drainage of wetlands, and introduction of agriculture.

F-2. Human activities in the central Delta have contributed to subsidence of much of the area. Some areas are now more than 20 feet below sea level.

F-3. Most of the soils in the central Delta are designated "prime" and of statewide value for agriculture.

F-4. The peat soils have subsided largely through oxidation; other activities resulting in subsidence include cycles of drain and flood, wind, and burning.

F-5. While over 95% of all wetlands in the Delta have been lost, the Delta area is used by 10% of the wintering waterfowl traveling within the Pacific Flyway.

F-6. Valuable habitat for many birds and mammals is included on linear riparian corridors along levees and small isolated areas located on the islands and small channel islands, and Delta wetlands. Agricultural lands also provide high if quality wildlife habitat and foraging areas, depending on agricultural practices. The levees keep flooding from occurring, which would destroy habitat. Levees are manmade structures which have no initial habitat value when constructed. The value of wildlife and habitat on the levees is dependent on the maintenance of the levees.

F-7. The value to wildlife of levee habitat and habitat within the levees is lessened by on-going human impacts such as levee maintenance, farm practices, human habitation, and recreational use of the levees and waterways. Activities such as water transport and boating use have eroded Delta channel islands, berms, and levees destroying habitat areas. Without levee maintenance, the habitat on the levees and within the islands will be lost.

F-8. The native population of fish and other aquatic species has been modified by hydromodification including water diversion, etc., through introduction of exotic species and other causes. Numbers of both native and of some introduced fish have dropped dramatically since the late 1960's; numbers have dropped so low that winter-run Chinook salmon and Delta smelt have been listed as endangered and threatened, respectively. However, the population of some introduced species of fish and other introduced aquatic species throughout the aquatic food chain has substantially increased.

F-9. There is no Delta regionwide management plan for wildlife resources.

F-10. Most of the Delta is located in the 100-year flood plain. While the levee system is constantly being maintained and upgraded, many Delta islands have been temporarily flooded; at least four have remained flooded. Permanent flooding, such as seen on Frank's Tract, would adversely impact utility infrastructure, residential and recreational facilities, farmlands, wildlife habitat, transportation, commerce, and fisheries. Evaporation from flooded islands consumes substantially more water than is needed to farm those islands.

F-ll. The Primary Zone, with its large open expanses of farmland, mosaic of small grain crop residues and shallow flooded fields, permitting wildlife to feed and rest, provides extremely high quality wildlife habitat.

F-12. Seasonal flooding in fall and winter has traditionally been carried out to serve several purposes: weed control, leaching of soils, control of oxidation of peat soils, provision of seasonal habitat, and hunting.

F-13. Delta channel islands and levees serve as habitat for several burrowing species, including beaver and muskrat. Some species have created burrows large enough to endanger levee stability.

* Findings Adopted by Delta Protection Commission on February 23, 1995.

Environment Policies: *

P-1 The priority land use of areas of prime soil shall be agriculture. If commercial agriculture is no longer feasible due to subsidence or lack of adequate water supply or water quality, land uses which protect other beneficial uses of Delta resources, and which would not adversely affect agriculture on surrounding lands, or viability or cost of levee maintenance, may be permitted. If temporarily taken out of agriculture production due to lack of adequate water supply or water quality, the land shall remain reinstateable to agricultural production for the future.

P-2. Agricultural and land management practices shall minimize subsidence of peat soils. Local governments shall support study of agricultural methods which minimize subsidence and assist in educating landowners and managers as to the value of utilizing these methods.

P-3. Lands managed primarily for wildlife habitat shall be managed to provide several inter-related habitats. Delta-wide habitat needs should be addressed in development of any wildlife habitat plan. Appropriate programs, such as "Coordinated Resource Management and Planning" and "Natural Community Conservation Planning" should ensure full participation by local government and property owner representatives.

* Policies Adopted by Delta Protection Commission on February 23, 1995.

Environment Recommendations: *

R-l. Seasonal flooding should be carried out in a manner so as to minimize mosquito production. Deltawide guidelines outlining "best management practices" should be prepared and distributed to land managers.

R-2. Wildlife habitat on the islands should be of adequate size and configuration to provide significant wildlife habitat for birds, small mammals, and other Delta wildlife.

R-3. Undeveloped channel islands provide unique opportunities for permanent wildlife habitat in the Primary Zone. A strategy should be developed to encourage permanent protection and management of the channel islands. Protection may include: acquisition, conservation easements, or memoranda of understanding. Management may include: protection from erosion, controlling human access, or habitat management, such as planting native plants and removing exotic plants. Some larger, reclaimed channel islands may be suitable for mixed uses, such as recreation and habitat. Any development on channel islands must ensure long-term protection of the wildlife habitat.

R-4. Feasible steps to protect and enhance aquatic habitat should be implemented as may be determined by resource agencies consistent with balancing other beneficial uses of Delta resources.

R-5. Publicly-owned land should incorporate, to the maximum extent feasible, suitable and appropriate wildlife protection, restoration and enhancement as pan of a Delta-wide plan for habitat management.

R-6. Management of suitable agricultural lands to maximize habitat values for migratory birds and other wildlife should be encouraged. Appropriate incentives, such as conservation easements, should be provided by non-profits or other entities to protect this seasonal habitat through donation or through purchase.

R-7. Lands currently managed for wildlife habitat, such as private duck clubs or publicly-owned wildlife areas, should be preserved and protected, particularly from destruction from inundation.

* Recommendations Adopted by Delta Protection Commission on February 23, 1995.

# Appendix A

# Special Status Species of the Sacramento-San Joaquin Delta

Special Status Species of the Sacramento-San Joaquin Delta

| | COMMON NAME | SCIENTIFIC NAME | USFWS | STATUS CDFG | CNPS |
|---|---|---|---|---|---|
| PLANTS | Suisun marsh aster | Aster lentus | C2 | - | IB |
| | California hibiscus | Hibiscus lasiocarpus | - | - | 2 |
| | Delta tule pea | Lathyrus jepsonii var. jepsonii | C2 | - | IB |
| | Mason's lilaeopsis | Lilaeopsis masonii | C2 | R | IB |
| | Delta mudwort | Limosella subulata | - | - | 2 |
| | Antioch Dunes evening primrose | Oenothera deltoides ssp. howellii | E | E | IB |
| | Sanford's arrowhead | Sagiltaria sanfordii | C2 | - | IB |
| | Marsh skullcap | Scutellaria galericulata | - | - | 2 |
| BIRDS | Tricolored blackbird | Agelaius tricolor | C2 | SC | - |
| | Aleutian Canada goose | Branta canadensis leucopareia | T | . | . |
| | Swainson's hawk | Buteo swainsoni | C3 | T | - |
| | Greater sandhill crane | Grus canadensis tabida | - | T | - |
| | California black rail | Laterallus jamaicensis coturniculus | C2 | T | . |
| MAMMALS | Salt-marsh harvest mouse | Reithrodontomys raviventris | E | E | - |
| | San Joaquin kit fox | Vulpes macrotis mutica | E | T | - |
| REPTILES | Western pond turtle | Clemmys marmorata | C2 | SC | - |
| | Giant garter snake | Thamnophis gigas | T | T | - |
| INSECTS | Antioch Dunes anthicid beetle | Anthicus antiochensis | C2 | _ | . |
| | Sacramento anthicid beetle | Anthicus sacramento | C2 | - | - |
| | Valley elderberry longhorn beetle | Desmocerus californicus dimorphus | T | . | _ |
| FISH | Delta smelt | Hypomesus transpacificus | T | T | - |
| | Winter-run chinook salmon | Oncorhynchus tshawytscha | E | E | - |
| | Sacramento splittail | Pogonichthys macrolepidotus | P(T) | SC | . |